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COOLING SYSTEM FOR WORK MACHINE

Cross Reference to Prior Related Applications

This application is a U.S. national phase application under 35 U.S.C. § 371 of International Patent Application No. PCT/JP2005/014068, filed August 2, 2005, and claims the benefit of Japanese Patent Application No. 2004-365112, filed December 16, 2004, both of which are incorporated by reference herein. The International Application was published in Japanese on June 22, 2006 as International Publication No. WO 2006/064588 A1 under PCT Article 21(2).

Technical Field

The present invention relates to a cooling system for a work machine, the cooling system being provided with a cooling package that includes heat exchangers and a cooling fan.

Background Art

As shown in Fig. 18, a hydraulic excavator, which is a work machine, contains a lower structure 1 and an upper structure 2, which is rotatably mounted on the lower structure 1, with a swiveling bearing portion disposed between the upper structure 2 and the lower structure 1. A

power system covered by a cover 3, as well as a cab 4 and a work equipment 5, are mounted on the upper structure 2.

The cover 3 includes an upper cover 3a affixed to one side of the cover 3 and an openable/closable side door 3b attached to the upper cover 3a. Upper air intake holes 6 are formed in the upper cover 3a. Side air intake holes 7 are formed in the upper part of the side door 3b.

As shown in Fig. 19, a power chamber provided inside the cover 3 incorporates power system components including a cooling package, an engine 13, a hydraulic pump 14, and a muffler 15. The cooling package is comprised of a cooling fan 12 integrated with a heat exchanger unit 11 provided for such devices as a radiator, an oil cooler, etc.

In order to cool the engine 13, cooling air, i.e. the outside air, introduced from the upper air intake holes 6 and the side air intake holes 7 is caused by the cooling fan 12 to pass through the heat exchanger unit 11 of the cooling package and, after passing by the engine 13 and the hydraulic pump 14, is discharged to the outside through an exhaust port formed in the cover 3, at a location near the muffler 15.

With the configuration as above, as shown in Fig. 20, there is no shielding member between the air intake holes 6, 7 of the cover 3 and the engine 13 together with its accessory components. The absence of a shielding member causes sound generated inside the power chamber, such as engine sound and noises produced by the cooling fan 12, that is represented by arrows depicted as a dotted line, to

escape through the aforementioned air intake holes 6, 7 directly to the outside, resulting in the possible increase of ambient noise.

The configuration described above presents another problem in that currents of cooling air (represented by arrows depicted as a solid line) flowing from the upper air intake holes 6 and the side air intake holes 7 into the power chamber collide and converge with one another and produce turbulence in an area A in front of the heat exchanger unit 11, resulting in a decrease in efficiency of intake of cooling air.

In order to solve the above problems, there have conventionally been provided cooling systems having a structure that calls for forming upper and lower air intake holes in the top and bottom (instead of in a side) of an engine cover to introduce cooling air into the inside of the engine cover and also installing upper and lower air ducts for directing cooling air introduced through the upper and lower air intake holes towards the front side of an heat exchanger unit 11 (e.g., Japanese Laid-Open Patent Publication No. 2000-16094 (pages 4-5, Fig. 2) ("JP '094")).

The structure disclosed in JP '094 is complicated in that the absence of air intake holes at a side of the engine cover reduces the efficiency of air intake by the cooling fan and, for this reason, makes it necessary to provide upper and lower air ducts that communicate with upper and lower air intake holes as well as making it necessary for the upper and lower air ducts to have the ability of regulating air current in order to prevent

intermixing of cooling air introduced from these holes and ducts. Furthermore, as the lower air intake holes are formed at a location above the crawler belts of the lower structure, there is the possibility of earth, sand, dust and other similar substances conveyed onto the upper part of the crawler belts being sucked into the power chamber through the lower air intake holes.

In order to solve these problems, a structure shown in Fig. 21 has been offered, wherein a sound insulating/flow regulating plate 17 inclined at a given angle of 45° or greater to a horizontal plane is immovably provided in front of a heat exchanger unit 11 of a cooling package so that it is not possible to view the entire surface of the heat exchanger unit 11 directly through the upper air intake holes 6 of the upper cover 3a or the side air intake holes 7 of the side door 3b. This structure prevents an increase in ambient noises resulting from escape of sounds of the engine and the cooling fan, and also prevents reduction of the air intake efficiency that would otherwise be caused by turbulence generated by cooling air currents from the upper air intake holes 6 and the side air intake holes 7 colliding in front of the heat exchanger unit 11.

Summary of the Invention

Problems to be Solved by the Invention

According to a structure shown in Fig. 21, the angle at which the sound insulating/flow regulating plate 17 is affixed varies because intake speed, angle, and other

conditions of and proportions between the respective intake air 18 from the upper air intake holes 6 of the upper cover 3a and intake air 19 from the side air intake holes 7 of the side door 3b widely vary, depending on various conditions of the hydraulic excavator equipped with the cooling system, including the shape and performance characteristics, which differ depending on the type of the hydraulic excavator, as well as the conditions under which it is operating.

To be more specific, the optimal mounting angle of the sound insulating/flow regulating plate 17 for the shape and performance of each machine type widely varies. Moreover, even if the type of the machine is the same or similar, the amount of intake air and its intake angle vary depending on operating conditions. Therefore, a conventional sound insulating/flow regulating plate 17 that is affixed to the engine cover is incapable of coping with such variation.

Furthermore, should such a conventional sound insulating/flow regulating plate 17 be affixed at an appropriate angle, the sound insulating/flow regulating plate 17 would function as intake resistance, and thereby cause an increase in the pressure loss at the air intake side, resulting in a reduced air intake efficiency. On the other hand, calculation of an appropriate mounting angle of the sound insulating/flow regulating plate 17 requires a tremendous amount of time for analysis.

Furthermore, a conventional, fixed-type sound insulating/flow regulating plate 17 presents a problem when conducting maintenance; should the sound insulating/flow

regulating plate 17 be located in front of the heat exchanger unit 11 when accessing from the side door to clean the heat exchanger unit 11 of the cooling package, it may be difficult or impossible to clean some parts.

When cleaning the heat exchanger unit 11, it is also necessary to remove a screen disposed at the front end of the heat exchanger unit 11. As the screen can be accessed only from a gap between the heat exchanger unit 11 and the sound insulating/flow regulating plate 17, removal of the screen is not only difficult but also may damage the heat exchanger unit 11. Furthermore, as the gap between the heat exchanger unit 11 and the sound insulating/flow regulating plate 17 is narrow, insertion of the nozzle of a cleaning instrument is difficult and may damage the heat exchanger unit 11.

In order to facilitate cleaning of the heat exchanger unit 11 of the cooling package, there has been provided a structure that calls for enabling the heat exchanger unit 11 to be swung outward. However, the presence of a sound insulating/flow regulating plate 17 may prevent the swinging motion of the heat exchanger unit 11, making it impossible to clean the heat exchanger unit 11.

In order to solve the above problems, an object of the invention is to provide a cooling system for a work machine including a sound insulating/flow regulating plate that is capable of coping with different types and operating conditions of a work machine. Another object of the invention is to provide a cooling system for a work machine

including a sound insulating/flow regulating plate that facilitates maintenance of a cooling package.

Means for Solving the Problems

The present invention relates to a cooling system for a work machine, the cooling system containing a cooling package, an upper cover, a side cover, upper air intake holes, side air intake holes, and a sound insulating/flow regulating plate. The cooling package includes a heat exchanger unit and a cooling fan. The upper cover is disposed above the cooling package. The side cover is provided at one side of the upper cover and faces the cooling package. Upper air intake holes open to the space between the side cover and the cooling package and are formed in the upper cover. Side air intake holes are formed in the upper part of the side cover, at a location adjacent to the upper cover. The sound insulating/flow regulating plate is adapted to move between the upper air intake holes and the side air intake holes and serves to block sound generated inside the machine body and also regulates the flow of air introduced from the upper air intake holes and the side air intake holes. As the sound insulating/flow regulating plate is designed such that the proportion of wind pressures applied to the sound insulating/flow regulating plate by the flow of air introduced from the upper air intake holes of the upper cover and the flow of air introduced from the side air intake holes of the side cover automatically sets the sound insulating/flow regulating plate to an optimal state to regulate the aforementioned air flows, in other words a

balance is achieved between wind pressures applied to the sound insulating/flow regulating plate by air respectively introduced from two locations, i.e., through the air intake holes, smooth, effective air intake is ensured without impairing the flow of cooling air or increasing air pressure loss. At that time, by regulating flows of air by preventing the air introduced from the upper air intake holes of the upper cover and the air introduced from the side air intake holes of the side cover from directly colliding and generating turbulence, the sound insulating/flow regulating plate is capable of automatically coping with different operating conditions or types of the work machines. Furthermore, the sound insulating/flow regulating plate, which is inclined at such an angle as to attain a balance between wind pressures applied by the flow of air introduced from the upper air intake holes and the flow of air introduced from the side air intake holes, is capable of reducing noises escaping outside the machine by blocking noises that are generated inside the machine body and escape from the front panel of the cooling package.

The present invention further relates to a cooling system for a work machine as described above, wherein the cooling system further includes a swing shaft means disposed between the upper air intake holes and the side air intake holes, and the sound insulating/flow regulating plate is swingably supported by the swing shaft means. Thus supporting the sound insulating/flow regulating plate so as to be capable of swinging by using the swing shaft means simplifies attachment configuration of the sound insulating/flow regulating plate.

The present invention further relates to a cooling system for a work machine as described above, wherein the cooling system further includes hinges for attaching the base edge of the sound insulating/flow regulating plate to the underside of the upper cover, and a locking means for securing the distal edge of the sound insulating/flow regulating plate to the underside of the upper cover when the sound insulating/flow regulating plate is in the folded state. With the configuration as above, by securing the sound insulating/flow regulating plate with the locking means after swinging the sound insulating/flow regulating plate around the hinges to fold the sound insulating/flow regulating plate up against the underside of the upper cover, which is not located immediately in front of the cooling package, cleaning and other maintenance of the cooling package is facilitated without the sound insulating/flow regulating plate obstructing maintenance operation.

The present invention further relates to a cooling system for a work machine as described above, wherein the cooling system includes a plurality of sound insulating/flow regulating plates. The particular benefit of having the plurality of sound insulating/flow regulating plates is an improved ability of regulating the air flow.

The present invention further relates to a cooling system for a work machine as described above, wherein the side cover is a side door that can be opened outwards and back, and the sound insulating/flow regulating plate is attached to the side door. With the configuration as above,

the sound insulating/flow regulating plate attached to the side door can be kept out of the way from the cooling package by opening the side door outward. Therefore, the configuration as above facilitates maintenance of the cooling package without the sound insulating/flow regulating plate obstructing maintenance operation.

The present invention further relates to a cooling system for a work machine as described above, wherein the cooling system further includes an actuator for operating the sound insulating/flow regulating plate, temperature sensors for detecting temperature data of the cooling package, and a control means for controlling the angle of the sound insulating/flow regulating plate by controlling the actuator based on temperature data from the temperature sensors. With the configuration as above, by moving the sound insulating/flow regulating plate by means of the actuator based on the temperature of the cooling package detected by the temperature sensor so as to adjust the amount or path of the air introduced from the upper air intake holes of the upper cover or the side air intake holes of the side cover, the control means enables the cooling system to cope with changes in operating conditions of the work machine.

The present invention further relates to a cooling system for a work machine as described above, wherein the heat exchanger unit of the cooling package contains a plurality of devices selected from among a heat exchanger of a radiator serving to cool cooling water for an engine, a heat exchanger of an oil cooler serving to cool hydraulic fluid in a hydraulic circuit, a condenser of an air

conditioner circuit, and a heat exchanger of an aftercooler serving to cool engine intake air compressed by a turbo supercharger, and the sound insulating/flow regulating plate is adapted so that the position of the sound insulating/flow regulating plate is adjustable to accommodate the combination structure of the selected devices and the cooling fan. With the configuration as above, even if the overall temperature distribution of the cooling package changes due to variation of arrangement of the heat exchanger of the radiator, the heat exchanger of the oil cooler, the condenser of the air conditioner circuit, and the heat exchanger of the aftercooler, in combination with the cooling fan, the present invention is capable of appropriate distribution of intake air for the temperature distribution by adjusting the position to which the sound insulating/flow regulating plate is moved.

According to the present invention, as the sound insulating/flow regulating plate is designed such that the proportion of wind pressures applied to the sound insulating/flow regulating plate by the flow of air introduced from the upper air intake holes of the upper cover and the flow of air introduced from the side air intake holes of the side cover automatically sets the sound insulating/flow regulating plate to an optimal state to regulate the aforementioned air flows, in other words a balance is achieved between wind pressures applied to the sound insulating/flow regulating plate by air respectively introduced from two locations, i.e., through the air intake holes, smooth, effective air intake is ensured without impairing the flow of cooling air or increasing air pressure loss. At that time, by regulating flows of air by

preventing the air introduced from the upper air intake holes of the upper cover and the air introduced from the side air intake holes of the side cover from directly colliding and generating turbulence, the sound insulating/flow regulating plate is capable of automatically coping with different operating conditions or types of the work machines. Furthermore, the sound insulating/flow regulating plate, which is inclined at such an angle as to attain a balance between wind pressures applied by the flow of air introduced from the upper air intake holes and the flow of air introduced from the side air intake holes, is capable of reducing noises escaping outside the machine by blocking noises that are generated inside the machine body and escape from the front panel of the cooling package.

The present invention further provides a simple attachment configuration of the sound insulating/flow regulating plate, wherein the sound insulating/flow regulating plate is swingably supported by the swing shaft means.

Furthermore, according to the present invention, by securing the sound insulating/flow regulating plate with the locking means after swinging the sound insulating/flow regulating plate around the hinges to fold the sound insulating/flow regulating plate up against the underside of the upper cover, which is not located immediately in front of the cooling package, cleaning and other maintenance of the cooling package is facilitated without the sound insulating/flow regulating plate obstructing maintenance operation.

Furthermore, according to the present invention, the plurality of sound insulating/flow regulating plates regulate the air flow with an improved ability.

Furthermore, according to the present invention, as the sound insulating/flow regulating plate attached to the side door can be kept out of the way from the cooling package by opening the side door outward, maintenance of the cooling package is facilitated without the sound insulating/flow regulating plate obstructing maintenance operation.

Furthermore, according to the present invention, by moving the sound insulating/flow regulating plate by means of the actuator based on the temperature of the cooling package detected by the temperature sensor so as to adjust the amount or path of the air introduced from the upper air intake holes of the upper cover or the side air intake holes of the side cover, the control means enables the cooling system to cope with changes in operating conditions of the work machine.

Furthermore, according to the present invention, even if the overall temperature distribution of the cooling package changes due to variation of arrangement of the heat exchanger of the radiator, the heat exchanger of the oil cooler, the condenser of the air conditioner circuit, and the heat exchanger of the aftercooler, in combination with the cooling fan, the present invention is capable of appropriate distribution of intake air for the temperature

distribution by adjusting the position to which the sound insulating/flow regulating plate is moved.

Brief Description of the Drawings

Fig. 1 is a sectional view of a first embodiment of a cooling system for a work machine according to the present invention.

Fig. 2 is a perspective of a power system of the aforementioned first embodiment.

Fig. 3 is a perspective of a side cover of the first embodiment.

Fig. 4(a) is a perspective of a side cover of a second embodiment of a cooling system, and

Fig. 4(b) is an enlarged perspective of the related part of the side cover.

Fig. 5(a) is a perspective of a sound insulating/flow regulating plate of the cooling system according to the aforementioned second embodiment, showing the sound insulating/flow regulating plate in a folded state, and Fig. 5(b) is an enlarged perspective of the related part of the sound insulating/flow regulating plate.

Fig. 6 is a sectional view of a third embodiment of a cooling system.

Fig. 7 is a sectional view of a fourth embodiment of a cooling system.

Fig. 8 is a sectional view of a fifth embodiment of a cooling system.

Fig. 9 is a sectional view of a sixth embodiment of a cooling system.

Fig. 10 is a sectional view of a seventh embodiment of a cooling system.

Fig. 11 is a flow chart showing the control steps according to the aforementioned seventh embodiment.

Fig. 12 is a perspective of a first embodiment of a cooling package of the cooling system.

Fig. 13 is a perspective of a second embodiment of a cooling package.

Fig. 14 is a perspective of a third embodiment of a cooling package.

Fig. 15 is a perspective of a fourth embodiment of a cooling package.

Fig. 16 is a perspective of a fifth embodiment of a cooling package.

Fig. 17 is a perspective of a sixth embodiment of a cooling package.

Fig. 18 is a perspective of a hydraulic excavator as a work machine.

Fig. 19 is a sectional view of a power system of the hydraulic excavator.

Fig. 20 is a sectional view of an example of a conventional air intake system for a cooling package of the aforementioned power system.

Fig. 21 is a sectional view of an improved version of the aforementioned air intake system.

Reference Numerals

Detailed Description of the Invention

Next, the present invention is explained hereunder, referring to various embodiments shown in Figs. 1 through 17. The hydraulic excavator serves as a work machine and is shown in Fig. 18, and is further referred to in the explanation of the present invention. Therefore, the elements corresponding to those in Fig. 18 are identified with the same reference characters.

A first embodiment of a cooling system for the hydraulic excavator is explained, referring to Figs. 1 through 3.

As shown in Fig. 1, a cooling package 21 is installed in a cooling system housing 20 of a hydraulic excavator. The cooling package 21 includes a cooling fan 12 and a heat exchanger unit 11 that is provided for various cooling components, such as a radiator for cooling an engine 13. The cooling package 21 and the engine 13 are covered by a cover 3, which contains an upper cover 3a and a side door 3b. The upper cover 3a is provided above the cooling package 21. The side door 3b is a side cover provided at one side of the upper cover 3a and faces the cooling package 21.

As shown in Fig. 2, whereas the upper cover 3a is secured, the side door 3b is attached to a supporting member 22 by means of a plurality of vertically arranged hinges 23 so that the side door 3b can smoothly be opened outwards and back. The aforementioned supporting member 22 is disposed behind a cab 4. A filter 24 for engine intake

air is provided near the cooling package 21. In Fig. 2, numeral 25 denotes a counterweight.

The cooling package 21 contains a heat exchanger 11ra of a radiator serving to cool cooling water for the engine 13, a heat exchanger 11oi of an oil cooler serving to cool hydraulic fluid in a hydraulic circuit, a condenser 11co of an air conditioner circuit, a heat exchanger 11af of an aftercooler serving to cool engine intake air compressed by a turbo supercharger, and the aforementioned cooling fan 12. The heat exchanger 11oi is disposed in front of and towards the lower part of the heat exchanger 11ra as viewed in Fig. 2. The heat exchanger 11co is disposed in front of the heat exchanger 11oi as viewed in Fig. 2. The heat exchanger 11af is disposed in front of and towards the upper part of part of the heat exchanger 11ra as viewed in Fig. 2. The cooling fan 12 is disposed behind the heat exchanger 11ra, i.e., between the engine 13 and the heat exchanger 11ra.

As shown in Figs. 1 through 3, a plurality of upper air intake holes 6 open to the space between the side door 3b and the cooling package and are formed in the upper cover 3a. A plurality of side air intake holes 7 are formed in the side door 3b, at a location adjacent to the upper cover 3a.

The base end of a sound insulating/flow regulating plate 27 is attached to the underside of the upper cover 3a by a pair of hinges 26 that are disposed between the upper air intake holes 6 and the side air intake holes 7 and serve as a swing shaft means so that the sound

insulating/flow regulating plate 27 can be swung around the hinges 26.

The sound insulating/flow regulating plate 27 is adapted so that its inclination can be changed depending on the proportion of a wind pressure of the air introduced from an aperture in the upper part of the machine body, i.e., the upper air intake holes 6, and a wind pressure of the air introduced from an aperture in the side door 3b, i.e., the side air intake holes 7. The sound insulating/flow regulating plate 27 functions to block noises generated inside the machine body, such as engine sound and fan noises, that escape through the upper air intake holes 6 and the side air intake holes 7 to the outside and also to regulate the flow of air introduced from the upper air intake holes 6 and the side air intake holes 7.

Fig. 3 shows the side door 3b provided with a handle 28, which serves to open or close the side door 3b, and a door closing portion 29 including a magnet and a lock. The handle 28 and the door closing portion 29 are provided at the end opposite the hinges 23.

Air intake holes 30a are formed on one side of the cover 3. As shown in Fig. 1, the air introduced through the air intake holes 30a, too, is sucked into the cooling package 21.

Next, functions and effects of the first embodiment shown in Figs. 1 through 3 are explained hereunder.

As the sound insulating/flow regulating plate 27 is capable of swinging around the hinges 26 disposed between the upper air intake holes 6 and the side air intake holes 7, the proportion of wind pressures applied to the sound insulating/flow regulating plate 27 respectively by the flow of air introduced from the upper air intake holes 6 of the upper cover 3a and the flow of air introduced from the side air intake holes 7 of the side door 3b automatically sets the sound insulating/flow regulating plate 27 at an optimal inclination angle to regulate the aforementioned air flows.

In other words, the sound insulating/flow regulating plate 27 designed as above makes it possible to achieve a balance between wind pressures applied to the sound insulating/flow regulating plate 27 by air respectively introduced from two locations, i.e., through the air intake holes 6 and 7. Therefore, the sound insulating/flow regulating plate 27 enables smooth, effective air intake without impairing the flow of cooling air or increasing air pressure loss.

At that time, the sound insulating/flow regulating plate 27 also regulates flows of air by preventing the air introduced from the upper air intake holes 6 of the upper cover 3a and the air introduced from the side air intake holes 7 of the side door 3b from directly colliding and generating turbulence. The sound insulating/flow regulating plate 27 is capable of automatically coping with different operating conditions or types of the hydraulic excavators.

Furthermore, the sound insulating/flow regulating plate 27, which is inclined at such an angle as to attain a balance between wind pressures applied by the flow of air introduced from the upper air intake holes 6 and the flow of air introduced from the side air intake holes 7, is capable of reducing noises escaping outside the machine by blocking engine sound and fan noises that escape from the front panel of the heat exchanger unit 11 of the cooling package 21.

Figs. 4 and 5 show a second embodiment of a cooling system, wherein the elements corresponding to those in Fig. 3 are identified with the same reference symbols, explanation of which are omitted.

As shown in Figs. 4 and 5, the base edge of a sound insulating/flow regulating plate 27 is swingably attached to the underside of an upper cover 3a by a pair of hinges 26, whereas the distal edge of the sound insulating/flow regulating plate 27 can be fixed to the underside of the upper cover 3a by a locking means 31 when the sound insulating/flow regulating plate 27 is in the folded state.

The locking means 31 contains a fitting 32 shown in Fig. 5(b), a slide pin 33, a pin catching portion 34, and an operating portion 35 for sliding the slide pin 33. As shown in Fig. 4(b), the slide pin 33 is disposed at the approximate center of the distal edge of the sound insulating/flow regulating plate 27, i.e., the edge opposite the hinges 26, and is attached to the sound insulating/flow regulating plate 27 by means of the fitting 32 so that the slide pin 33 is capable of protruding and

retreating from the distal edge of the sound insulating/flow regulating plate 27. As shown in Fig. 4(b), the pin catching portion 34 is attached to the underside of the distal edge, i.e., the edge opposite the hinges 26, of the upper cover 3a, with the upper air intake holes 6 located between the hinges 26 and the pin catching portion 34. As shown in Fig. 5(b), the pin catching portion 34 is adapted to catch the slide pin 33 when the slide pin 33 sticks out. The aforementioned operating portion 35 protrudes from the slide pin 33.

The locking means for securing the sound insulating/flow regulating plate 27 to the upper cover 3a is not limited to the structure described above; it may be composed of a fixing means using a bolt, a strong magnet, or any other appropriate means.

As described above, while being swingably supported by the hinges 26 through shafts, the sound insulating/flow regulating plate 27 can be secured to the underside of the upper cover 3a by the locking means 31. Therefore, when cleaning the heat exchanger unit 11 of the radiator and other devices of the cooling package 21, the sound insulating/flow regulating plate 27 is secured at the upward position as shown in Fig. 5 so as not to be in front of the heat exchanger unit 11 before cleaning the cooling package 21. Thereafter, the necessary procedure is followed, such as removing a screen (not shown) that is disposed at the front part of the heat exchanger unit 11, inserting a cleaning nozzle, or swinging the heat exchanger unit 11 outward.

In other words, by bringing the slide pin 33 to protrude from the distal edge of the sound insulating/flow regulating plate 27 and be engaged with the pin catching portion 34 after swinging the sound insulating/flow regulating plate 27 around the hinges 26 to fold the sound insulating/flow regulating plate 27 up against the underside of the upper cover 3a as shown in Figs. 4 and 5, the sound insulating/flow regulating plate 27 is secured to the underside of the upper cover 3a. Thus securing the sound insulating/flow regulating plate 27 to the underside of the upper cover 3a, which is not located immediately in front of the cooling package 21, facilitates maintenance of the cooling package 21, including cleaning entire surface of the heat exchanger unit 11, which includes heat exchangers of the radiator and other devices, without the sound insulating/flow regulating plate 27 obstructing maintenance operation.

The feature of the second embodiment described above also facilitates removal of the screen, which is provided at the front end of the heat exchanger unit 11, when cleaning the heat exchanger unit 11. Furthermore, the embodiment also reduces the possibility of damage to the heat exchanger unit 11 by eliminating the necessity of inserting a cleaning nozzle into a narrow gap while avoiding the conventional downward-inclined sound insulating/flow regulating plate 27.

Furthermore, in cases where the cooling package 21 is provided with a heat exchanger unit 11 that can be swung outward in order to facilitate cleaning the heat exchanger unit 11, the foldable sound insulating/flow regulating

plate 27 enables swinging motion of the heat exchanger unit 11, facilitating cleaning of the heat exchanger unit 11.

When starting the engine 13 at a low ambient temperature, folding up the sound insulating/flow regulating plate 27 as shown in Fig. 5 to block the flow of the air introduced from the upper air intake holes 6 limits the cooling capacity of the cooling package 21, thereby preventing overcooling and ensuring efficient warming up.

Fig. 6 shows a third embodiment of a cooling system, wherein the elements corresponding to those in Fig. 1 are identified with the same reference symbols, explanation of which will be omitted.

As shown in Fig. 6, a plurality of sound insulating/flow regulating plates 27 for blocking sound generated inside the machine body, such as engine sound and fan noises, and also regulating the flow of air introduced from upper air intake holes 6 and side air intake holes 7 are swingably attached to the underside of an upper cover 3a by a plurality of hinges 26, 26a, etc., which collectively serve as a swing shaft means. The hinges 26 are disposed between the upper air intake hole 6 that is closest to the outer edge of the upper cover 3a and the side air intake holes 7. The hinges 26a are disposed between the upper air intake holes 6.

Each sound insulating/flow regulating plate 27 may be swung freely and independently of one another. Or, as is true in a configuration shown in Fig. 6, the sound insulating/flow regulating plates 27 may be connected to

one another by one or more interlocking links 36 or other appropriate means so that the sound insulating/flow regulating plates 27 can be swung while remaining spaced apart and parallel with one another.

As the sound insulating/flow regulating plates 27 are capable of swinging around the hinges 26, 26a, etc., the proportion of wind pressures applied to the sound insulating/flow regulating plates 27 respectively by the flow of air introduced from the upper air intake holes 6 of the upper cover 3a and the flow of air introduced from the side air intake holes 7 of the side door 3b automatically sets the angle of the sound insulating/flow regulating plates 27. Furthermore, the sound insulating/flow regulating plates 27, which are inclined at an optimal angle, are capable of reducing engine sound and fan noises that escape outside the machine from the upper air intake holes 6 and the side air intake holes 7. Moreover, the plurality of sound insulating/flow regulating plates 27 provide flow regulating function to prevent the air introduced from the upper air intake holes 6 of the upper cover 3a and the air introduced from the side air intake holes 7 of the side door 3b from directly colliding and generating turbulence. The particular benefit of having the plurality of sound insulating/flow regulating plates 27 lies in improved ability of regulating the air flow from the upper air intake holes 6.

Fig. 7 shows a fourth embodiment of a cooling system, wherein the elements corresponding to those in Fig. 1 are identified with the same reference symbols, explanation of which are omitted.

As shown in Fig. 2, the side door 3b is provided so that it can smoothly be opened outwards and back. In Fig. 7, a sound insulating/flow regulating plate 27 for blocking sound generated inside the machine body, such as engine sound and fan noises, and also regulating the flow of air introduced from the upper air intake holes 6 and the side air intake holes 7 is swingably attached to the side door 3b by hinges 26 that are disposed between the upper air intake holes 6 and the side air intake holes 7 and serve as a swing shaft means.

As described above, the sound insulating/flow regulating plate 27 in Fig. 7 is attached to the side door 3b, which opens outward. Therefore, when performing maintenance, the sound insulating/flow regulating plate 27 attached to the side door 3b can be kept out of the way from the cooling package 21 by opening the side door outward as shown in Fig. 2. This feature facilitates maintenance of the cooling package 21 inside the cooling system housing 20, such as cleaning the heat exchanger 11ra of the radiator, without the sound insulating/flow regulating plate 27 obstructing maintenance operation.

Fig. 8 shows a fifth embodiment of a cooling system, wherein the elements corresponding to those in Fig. 1 are identified with the same reference symbols, explanation of which are omitted.

As shown in Fig. 8, a cooling package 21 is covered by an upper cover 3a and a side door 3b, with upper air intake holes 6 and side air intake holes 7 formed in the upper

cover 3a and the side door 3b, respectively. A sound insulating/flow regulating plate 27 is attached to the underside of the upper cover 3a by hinges 26 that are disposed between the upper air intake holes 6 and the side air intake holes 7 and serve as a swing shaft means.

An actuator 41, which may be a solenoid or the like and serves to swing the sound insulating/flow regulating plate 27 around the hinges 26, is attached to the upper cover 3a and the sound insulating/flow regulating plate 27 by means of a shaft.

The cooling package 21 is provided with temperature sensors 42 for detecting temperature data, such as the temperature of engine cooling water in the radiator and the temperature of hydraulic fluid in the oil cooler in the hydraulic circuit. The engine 13 is provided with a temperature sensor 43 for detecting the internal temperature of the engine 13. Each temperature sensor 42 may be disposed in each respective pipeline through which the engine cooling water or the hydraulic fluid flows.

The temperature sensors 42, 43 are connected to a control panel 44 serving as a control means so that the control panel 44 controls the angle of the sound insulating/flow regulating plate 27 by controlling the actuator 41 based on temperature data from the temperature sensors 42, 43.

The control panel 44 may be connected to components, e.g., an axle dial and an engine speed sensor (not shown), that serve to set the no-load speed of the engine 13 and

adapted to receive data of rotation speed of the cooling fan 12 from these components so that the control panel 44 controls the angle of the sound insulating/flow regulating plate 27 by controlling the actuator 41 based on data of rotation speed of the cooling fan 12.

Next, functions and effects of the fifth embodiment shown in Fig. 8 are explained hereunder.

In cases where a temperature detected by any of the temperature sensors 42, 43, such as the temperature of the engine cooling water, the hydraulic fluid in the hydraulic circuit, or the internal temperature of the engine 13, is low, the control panel 44 controls the actuator 41 to swing the sound insulating/flow regulating plate 27 in such a direction as to cover the side air intake holes 7 of the side door 3b as shown by the thick two-dot chain line in Fig. 8 so that the great quantity of air introduced from the side air intake holes 7 generates turbulence and applies resistance to the air. The control panel 44 thus limits the cooling capacity of the cooling package 21 so as to prevent overcooling, thereby ensuring efficient warming up.

When the temperature of the engine cooling water, the hydraulic fluid in the hydraulic circuit, or the inside of the engine 13 detected by the corresponding temperature sensor 42, 43 has increased to a certain level, the control panel 44 terminates the warming up and swings the sound insulating/flow regulating plate 27 to the inclined position represented by the solid line in Fig. 8.

At that time, the angle of the sound insulating/flow regulating plate 27 is automatically controlled by means of the actuator 41, which may be a solenoid or the like, in response to changes in operating conditions of the hydraulic excavator so as to ensure smooth supply of air flow from the upper air intake holes 6 of the upper cover 3a and the side air intake holes 7 of the side door 3b to a high-temperature portion of the cooling package 21.

For example, when the temperature of the hydraulic fluid in the hydraulic circuit increases significantly due to operation of the hydraulic excavator under a heavy load, the sound insulating/flow regulating plate 27 is automatically adjusted to an angle more upward than a normal angle, thereby guiding the air introduced from the side air intake holes 7 towards the lower part of the cooling package 21 in order to increase the cooling efficiency of the oil cooler, which is disposed at the lower part of the cooling package 21.

At that time, the sound insulating/flow regulating plate 27 also regulates flows of air by preventing the air introduced from the upper air intake holes 6 of the upper cover 3a and the air introduced from the side air intake holes 7 of the side door 3b from directly colliding and generating turbulence. Therefore, smooth, effective air intake is ensured without impairing the flow of cooling air or increasing air pressure loss.

Furthermore, the sound insulating/flow regulating plate 27, which is controlled to the inclined position represented by the solid line in Fig. 8, is capable of

reducing noises escaping outside the machine by blocking engine sound and fan noises that escape from the front panel of the heat exchanger unit 11 of the cooling package 21 through the upper air intake holes 6 and the side air intake holes 7 to the outside.

In an alternative structure, two sound insulating/flow regulating plates 27 may be provided one on top of the other and supported by shafts so that each sound insulating/flow regulating plate 27 can be independently swung by each respective actuator 41. If such is the case, warming up can be performed with an increased efficiency by controlling one of the sound insulating/flow regulating plate 27 to cover the upper air intake holes 6 and the other to cover the side air intake holes 7.

Fig. 9 shows a sixth embodiment of a cooling system, wherein the elements corresponding to those in Figs. 6 and 8 are identified with the same reference symbols, explanation of which are omitted.

The cooling system includes an actuator 41, temperature sensors 42, 43, and a control panel 44. The actuator 41, which may be a solenoid or the like, serves to swing a plurality of sound insulating/flow regulating plates 27 through one or more interlocking links 36 around a plurality of hinges 26, 26a, etc., that collectively serve as a swing shaft means. The temperature sensors 42, 43 serve to detect temperatures of the cooling package 21 and the engine 13. The control panel 44 serves to control the angle of the sound insulating/flow regulating plates 27

by controlling the actuator 41 based on temperature data from the temperature sensors 42, 43.

With the configuration as above, in order to ensure smooth supply of air flow from the upper air intake holes 6 of the upper cover 3a and the side air intake holes 7 of the side door 3b to a high-temperature portion of the cooling package 21, the control panel 44 automatically controls the plurality of sound insulating/flow regulating plates 27 by detecting changes in operating conditions of the hydraulic excavator based on temperature data input from the temperature sensors 42, 43 and controlling the angle of the sound insulating/flow regulating plates 27 by means of the actuator 41. The particular benefit of having the plurality of sound insulating/flow regulating plates 27 lies in improved ability of regulating the air flow from the upper air intake holes 6.

Fig. 10 shows a seventh embodiment of a cooling system, wherein the elements corresponding to those in Figs. 7 and 8 are identified with the same reference symbols, explanation of which are omitted.

According to the embodiment shown in Fig. 10, a sound insulating/flow regulating plate 27 is swingably attached by hinges 26 to an upper cover 3a so as to face a side door 3b that can smoothly be opened outwards and back as shown in Fig. 2. An actuator 41, which may be a solenoid or the like, is attached to the upper cover 3a and the sound insulating/flow regulating plate 27 by means of a shaft.

The cooling system includes temperature sensors 42, 43 and a control panel 44. The temperature sensors 42, 43 serve to detect temperatures of the cooling package 21 and the engine 13. The control panel 44 serves to control the angle of the sound insulating/flow regulating plates 27 by controlling the actuator 41 based on temperature data from the temperature sensors 42, 43.

As described above, the sound insulating/flow regulating plate 27 is attached to the side door 3b, which opens outward. Therefore, when performing maintenance, the sound insulating/flow regulating plate 27 attached to the side door 3b can be kept out of the way from the cooling package 21 by opening the side door outward as shown in Fig. 2. This feature facilitates maintenance of the cooling package 21 inside the cooling system housing 20, such as cleaning the heat exchanger 11ra of the radiator, without the sound insulating/flow regulating plate 27 obstructing maintenance operation.

Fig 11 shows an example of control of the system according to the embodiment shown in Fig. 10. When starting up the engine 13, the sound insulating/flow regulating plate 27 at the side air intake holes 7 of the side door 3b should be in the closed state (Step 1).

When the engine 13 has been started up (Step 2), the control panel 44 determines whether the temperature of the engine cooling water that has been detected by a temperature sensor 42 is higher than a set temperature (Step 3). If the detected temperature is lower than the preset temperature (Step 3: NO), the control panel 44

decides that warming up of the engine 13 has not yet been completed and keeps the sound insulating/flow regulating plate 27 folded up in order to maintain the amount of the air introduced into the cooling system housing 20 at a low level, thereby limiting the cooling capacity of the cooling package 21 and continuing the warming up.

If the detected temperature is higher than the set temperature (Step 3: YES), the control panel 44 decides that warming up of the engine 13 has been completed and moves the sound insulating/flow regulating plate 27 by the actuator 41 to the controlled position represented by the solid line in Fig. 10 (Step 4).

By thus swinging the sound insulating/flow regulating plate 27 by means of the actuator 41 based on the temperature of the cooling package 21 detected by the temperature sensor 42 so as to adjust the amount or path of the air introduced from the side air intake holes 7 of the side door 3b, the control panel 44 enables the cooling system to cope with changes in operating conditions of the hydraulic excavator.

It is also possible for the control panel 44 to adjust the amount or path of the air introduced from the upper air intake holes 6 of the upper cover 3a by swinging the sound insulating/flow regulating plate 27 by means of the actuator 41, thereby enabling the cooling system to cope with changes in operating conditions of the hydraulic excavator.

Next, Figs 12 through 17 illustrate various embodiments of a cooling package 21. The cooling package 21 includes a combination of a plurality of devices selected from among a heat exchanger 11ra of a radiator serving to cool cooling water for the engine 13, a heat exchanger 11oi of an oil cooler serving to cool hydraulic fluid in the hydraulic circuit, a condenser 11co of an air conditioner circuit used for adjusting the temperature inside the cab 4, and a heat exchanger 11af of an aftercooler serving to cool engine intake air compressed by a turbo supercharger that is disposed in an air inlet system of the engine 13. Therefore, the position to which the sound insulating/flow regulating plate 27 is swung may be adjusted to accommodate the combination structure of these devices and the cooling fan 12.

For example, whereas Fig. 12 shows a combination of a heat exchanger 11ra of a radiator, a heat exchanger 11oi of an oil cooler, a condenser 11co of an air conditioner circuit, and a heat exchanger 11af of an aftercooler, Fig. 13 shows a combination of a combination of a heat exchanger 11ra of a radiator, a heat exchanger 11oi of an oil cooler, and a condenser 11co of an air conditioner circuit. In the case of the structure shown in Fig. 13, the inclination of the sound insulating/flow regulating plate 27 is controlled at a more downward angle so as to produce a higher passage resistance of the cooling air. As yet another alternative structure, Fig. 14 shows a combination of a heat exchanger 11ra of a radiator, a heat exchanger 11oi of a oil cooler, and a heat exchanger 11af of an aftercooler, wherein the inclination of the sound insulating/flow regulating plate

27 will be controlled at a more upward angle than in the case of the structure shown in Fig. 13.

Figs. 15, 16, and 17 respectively show examples of a structure wherein a heat exchanger 11af of an aftercooler extends from a heat exchanger 11ra of a radiator to a heat exchanger 11oi of an oil cooler. In any case, the inclination angle of the sound insulating/flow regulating plate 27 is adjusted to achieve an overall thermal balance.

Even if the overall temperature distribution of the cooling package 21 changes due to variation of arrangement of the heat exchanger 11ra of the radiator, the heat exchanger 11oi of the oil cooler, the condenser 11co of the air conditioner circuit, and the heat exchanger 11af of the aftercooler, the present invention is capable of appropriate distribution of intake air for the temperature distribution by adjusting the position to which the sound insulating/flow regulating plate 27 is swung.

Furthermore, according to any of the embodiments shown in the drawings, each sound insulating/flow regulating plate 27 is supported by hinges 26 or 26a that are disposed between the upper air intake holes 6 and the side air intake holes 7 and serve as a swing shaft means so that the sound insulating/flow regulating plate 27 is capable of swinging around shafts. In other words, according to any of the embodiments, each sound insulating/flow regulating plate 27 is attached by a simple means. However, depending on the circumstances, each sound insulating/flow regulating plate 27 may be provided between the upper air intake holes

6 and the side air intake holes 7 so as to be capable of sliding as guided.

The present invention is applicable to not only a cooling system of a hydraulic excavator but also a cooling system of any other work machine, such as a bulldozer or loader.